EFFECT OF ALUMINUM OXIDE AND SILICON CARBIDE ABRASIVE TYPE ON STAINLESS STEEL GROUND SURFACE INTEGRITY

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

High surface qualities of stainless steel product are important because the applications of stainless steel are wide in industry such as food storage, surgery tools and many more. Grinding process can produce stainless steel product with high surface quality. Grinding is an abrasive machining process that can machine up to ±0.0025 mm tolerance. Grinding is also a surface finishing process that used to improve surface finish and tighten the tolerance of a product. This study focused on the determination of the effect of Aluminum Oxide and Silicon Carbide grinder wheel on the stainless steel surface integrity. Besides that, the relation of the depth of cut and the cutting fluid usage with the crack length and surface roughness are determined. Optimum parameter that contributes to the better surface roughness and less crack length observed. The interaction among them then investigated and analyzed using ANOVA. Mixed Taguchi design of experiments approach used since there are multiple factors of parameters with multiple levels. From the result, ANOVA analysis will be carried out. Experimental results show that coolant usage is optimum in reducing the surface roughness. The interaction of coolant with the depth of cut indicates that coolant can improve surface roughness and extend the level of depth of cut. Meanwhile, crack length and it tendency to occur are less when the depth of cut are less because less residual stress and heat generated. Surface integrity of grinded stainless steel with the Aluminum Oxide grinder wheel is better comparing with the Silicon Carbide grinder wheel. The grindability of stainless steel workpiece materials was found to increase substaintially by using the Aluminum Oxide grinder wheels.

ABSTRAK

Kualiti permukaan produk stainless steel adalah penting kerana aplikasi stainless steel sangat luas dalam industri seperti penyimpanan makanan, alat-alat pembedahan dan banyak lagi. Proses grinding dapat menghasilkan produk stainless steel dengan kualiti permukaan yang tinggi. Grinding adalah proses pemesinan abrasive yang boleh memesin sehingga ±0,0025 mm tolarance. Grinding juga merupakan proses melicinkan permukaan dan digunakan untuk memperbaiki permukaan yang telah selesai dimesin serta merapatkan tolerance suatu produk. Kajian ini memfokuskan pada kesan Aluminium Oxide dan Silicon Carbide roda penggiling keatas integriti permukaan stainless steel. Selain itu, hubungan kedalaman potongan dan penggunaan cecair pemotongan dengan kepanjang retak dan kekasaran permukaan ditentukan. Optimum parameter yang memberikan sumbangan terhadap kekasaran permukaan yang lebih baik dan panjang retak yang sedikit diperhatikan. Interaksi antara mereka kemudian diteliti dan dianalisis menggunakan ANOVA. Pendekatan eksperiments Taguchi yang bercampur-campur digunakan kerana ada beberapa faktor parameter dengan beberapa tahap. Dari hasil kajian, analisis ANOVA akan dilakukan. Keputusan kajian menunjukkan bahawa penggunaan cecair penyejuk optimum dalam mengurangkan kekasaran permukaan. Interaksi cecair penyejuk dengan kedalaman potongan menunjukkan bahawa cecair penyejuk dapat mengurangkan kekasaran permukaan dan menambah tahap kedalaman potong. Sementara itu, panjang retak dan kecenderungan berlakunya keretakan kurang apabila kedalaman potong kurang kerana kurangnya residual stress dan pemansan dihasilkan. Integriti permukaan daripada bahan stainless steel yang telah digrind dengan roda penggiling Aluminium Oxide lebih baik berbanding dengan roda penggiling Silicon Carbide. Keupayaan untuk grinding bahan kerja stainless steel didapati meningkatkan dengan banyaknya menggunakan roda Aluminium Oxide.

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ρ	Density
μm	Micrometer
F_n	Normal force
F_t	Tangential force

LIST OF ABBREVIATIONS

Al_2O_3	Aluminum Oxide
ANOVA	Analysis of variance
ASME	American society of mechanical engineer
DF	Degree of fredoom
F	Ratio of two variance
MS	Mean square
H_A	Null hypothesis
H_O	Alternative hypothesis
SS	Sum square
P	Probability of obtaining a test statistic
Ra	Surface roughness
SiC	Silicon Carbide

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

One of the best method to produce a part or a workpiece that the material is too hard or too brittle and it require high dimensional accuracy and surface finish is by using abrasive machining. Grinding machining is a process of removing small chips or particle from material using the mechanical action of abrasive particle. The shapes of abrasive particles are in irregular shape, size, and hardness. Grinding is a finishing process which are used to improve surface finishing of materials, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces.

The process of removing chips from material occurs when the abrasive material rubs again the workpiece and remove the tiny pieces of the worpiece, i.e abrasive and the material to be worked are brought into contact while in relative motion to each other. Commonly, for grindng machine, the abrasives are bonded and compacted in wheel or belt shape and selected based on the purpose of the grinding process and type of material need to be grind.

Grinding wheels are compacted abrasive in wheel shape that are rotated at high speed. While once worked with a foot pedal or hand crank, the introduction of electric motors has made it necessary to construct the wheel to withstand greater radial stress to prevent the wheel flying apart as it spins.

Commonly, the grinding process were selected because the materials are too brittle to be machined economically. The materials may or may not have been hardened in order to produce a low-wear finish, such as stainless steel. Beside that, the grinding machine can machine up to ±0.0025 mm flatness tolarences. Griding process also can removes the excessive material for better surface finishing of product.

For industry application, the grinding process used to obtain high precesion surface finish such as in medical tools production, dies and tool production, gear and many more. High grade stainless steel are used for medical equipment required very fine tolarence.

1.2 PROJECT BACKGROUND

Commonly, grinding machine consist of a bed with fixture to guide and hold the workpice that need to be grind. It also contain power driven wheel that spin at the required speed. The grinding head can be controlled to travel across a fixed work piece or the workpiece can be moved whilst the grind head stays in a fixed position. To control the head or table of grinding, a vernier calibrated hand wheel were used. Another way to control it is by using the features of numerical.

In this study, a surface grinding will be used. Surface grinding is one of the most common operation and comprise the largest percentage grinders used in industry. In generally involves the grinding of flat surfaces. For surface grinder, the workpice need to grind were secured on a magnetic chuck which is attached to the table grinder. Fro nonmagnetic materials, its were held by vises, vacuum chucks or some other fixture.

A straight wheel of abrasive is mounted on the horizontal spindle of the surface grinder. As the table reciprocates longitudinally, the traverse occurs and its fed laterlly after each stroke in the direction of the spindle axis. When grinding, heat generation cannot be avoided. Therefore, coolant usage can reduce the heat generation to the workpiece, thus increasing the tool life and life cycle production.

Surface grinder can be devide into 3 major types, which is tranverse grinding, plunge grinding, and Blanchard type. Blanchard type is a vertical spindle and rotary table grinder.

There are several considerations in selecting grinding wheel for grinding process. One of them is the compatibility with the workpice. For Aluminum Oxide, it is recomended to grind steels, ferrous alloys and other high tensile materials. Silicon Carbide extensively used for grinding hard and dense material such as non-ferrous metals, non-metallic elements, and cast iron.

1.3 PROBLEMS STATEMENT

Grinding is a major surface finishing in most application in industry. Therefore, lots of studies of optimization parameters for grinding were done by many researcher to improve the surface integrity of grinding surface. In surface grinding, abrasive will effect the surfae integrity of the workpice. As well known, the force from grinding will cause crack on the surface of workpice as the depth of cut increase, thus generate heat. This condition also called heat checking. Other than that, grinding also can cause sparks, tempering and softening from excessive temperature rise, burning on the workpice surface, and residual stress.

The selection of abrasive and workpiece also important to increase the life cycle production, as well as increasing the tool life and grinding efficiency. Besides that, the abrasive will wear due to the rapid collision with the workpiece and need to be dressing. Aluminum Oxide wheel grinder have a small grain size particles, therefore it is a good abrasive in order to get smooth surface. But it tend to wear when cycle production is conducted and dressing is a compulsory. Meanwhile, the Silicon Carbide wheel grinder have a larger grain size particles, thus generate a rough surface finishing.

Stainless steels, one of alloy steel group, consist a minimum of 10.5% or 11% chromium and more than 50% iron content by mass. Its a corrosion resistance steel and have the antibacterial properties. The chromium content in stainless steel alloy is what generally prevents corrosion. Altough it is a corrosion ressistance steel, the temperature during grinding will cause the oxidation on the surface layer. Oxidation will cause corrosion on the surface of the stainless steel. The corrosion on the surface layer need to be avoided when the application of steel used in medical equipments, cookwares or food storages.

The significant of this study will increase the efficientcy of grinding process for the stainless steels products. The optimization of grinding parameters will generate better surface roughness.

1.4 PROJECT OBJECTIVES

There are several objectives in conducting this project. The lists of project's objectives are:

(i) To determine the effect of Aluminum Oxide and Silicon Carbide abrasives on the stainless steel surface integrity.

(ii) To determine the optimum grinding parameter process by manipulating depth of cut of the grinding and coolant usage with two type of wheels

(iii) To investigate the relation of surface crack on the workpiece with the depth cut of the grinding using SEM or microscope.

1.5 PROJECT SCOPES

The project scopes were determined based on the following specifications:

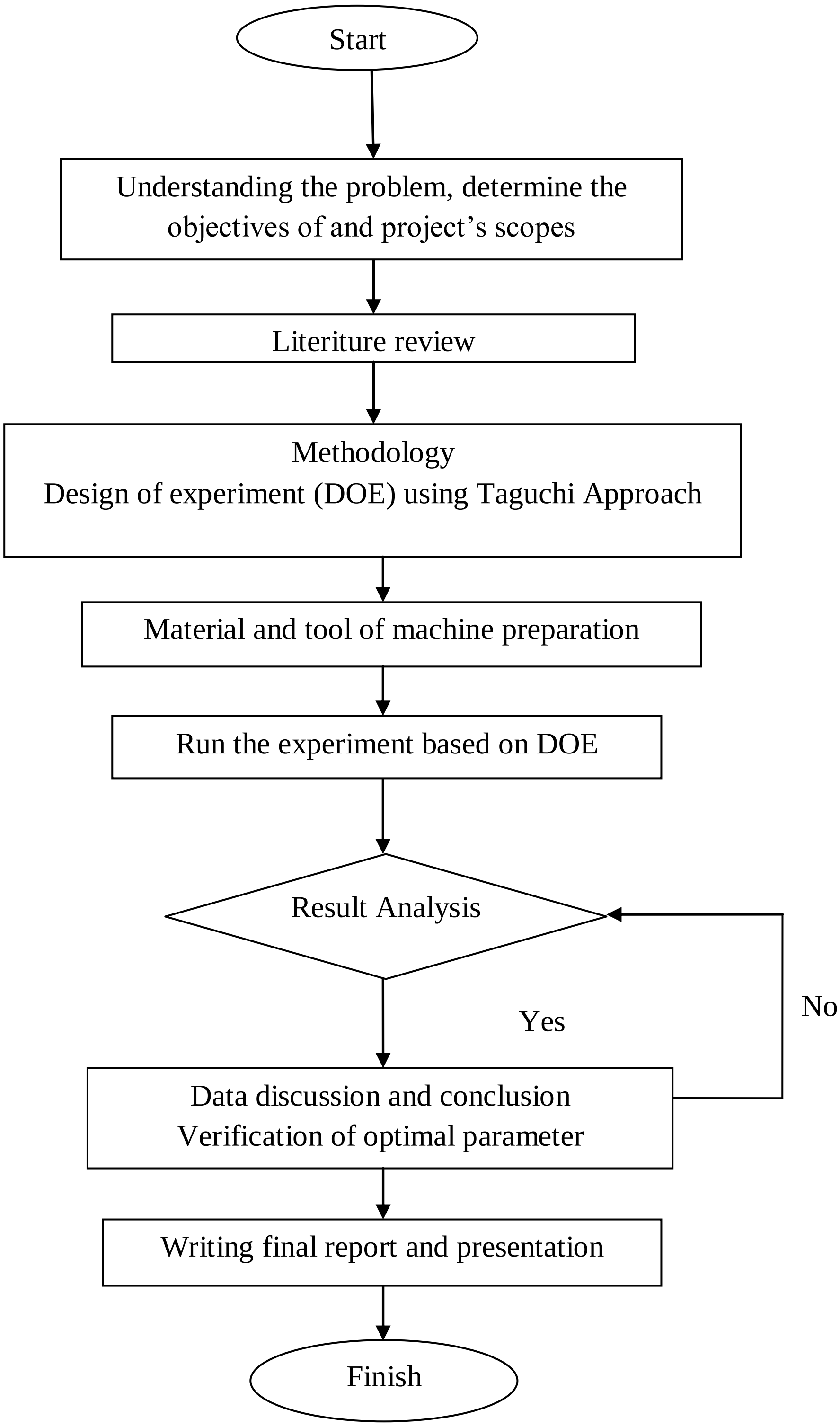
(i) The experimental will conduct based on DOE – Taguchi Approach

(ii) Identifying the parameter that should be considered in this experiment such as cutting fluid, feed rate, depth of cut, and spindle speed.

(iii) Selecting the abrasive usage based on the abrasive workpiece-material compatibility

(iv) The materials used are stainless steels

1.6 PROJECT FLOW CHART



CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

To produce a part that requires high dimensional accuracy and surface finishing, or the workpiece material that too hard or to brittle to process is using abrasive machining. Such characteristic can be obtained using grinding machine. Grinding machining is a process of removing small chips or particle from material using the mechanical action of abrasive particle. Fathallah et al. (2009) stated that the shapes of particle are in irregular shape, size, and hardness. This process can be either rough or precise operation, depending on the requirement of the product. For both internal and external grinding process, the medium required is the grinding wheels.

2.2 GRINDING MACHINE

2.2.1 Historical Perspective

According to American Society of Mechanical Engineers (ASME), grinding machine was first developed around 1830 – 1859. Surface-grinding machine was patented by J W Stone at Washington DC on 1831. And on 1834, grinding machine was developed and perhaps it was the first ever machine was developed. The developer of the grinding machine is Wheaton of Providence. The developments of grinding machines continued after that, and the revolution of grinding machine based on the purpose of the process. Figure 2.1 showed the time line of the development of the grinding machine.

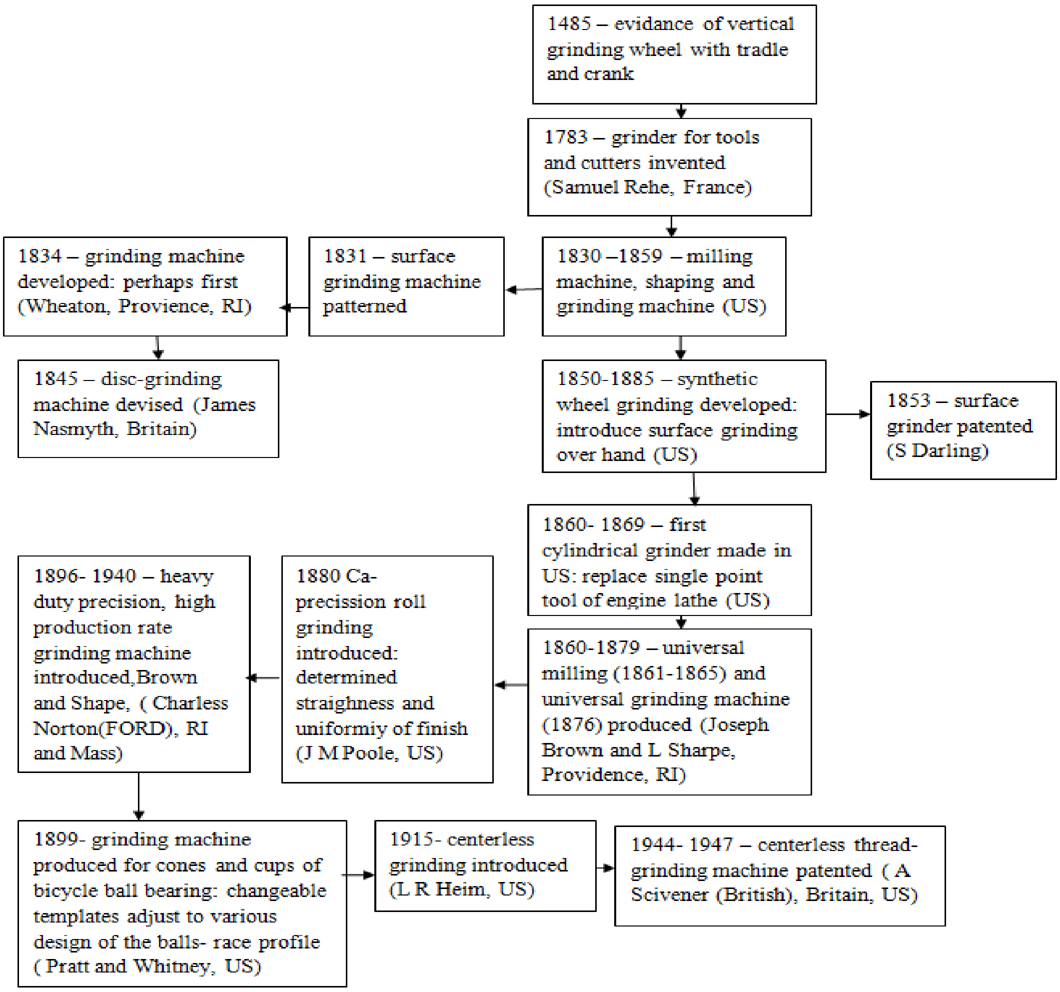


Figure 2.1: Schematic diagram of timeline of the developments of grinding machine

Adapted from: ASME

After the industrial revolution and World War II, many researchers did the development of grinding machine and the study to increase the efficiency and effectiveness because grinding process is a major surface finishing in industry.

2.2.2 Types of Grinding Process

Grinding process were selected based on the purpose of the grinding itself. There are several operation of grinding machine. Table 2.1 show the variety of grinding machine process.

Table 2.1: Variety of grinding process

Process	**Characteristics**	**Typical maximum dimensions,length and diameter, (m)**
Surface	Flats surfaces on most materials;production rate depends on the table size and level of automation;labor skill depends on part complexity;production rate is high on vertical – spindle rotary – table machines	Reciprocating table length: 6 Rotary table diameter: 3
Cylindrical	Round workpieces with stepped diameter ; low production rate unless automated; low to medium labor skill	Workpiece diameter: 0.8 Roll grinder diameter: 1.8 Universal grinder diameter: 2.5
Centerless	Round and slender workpieces; high production rate; low to medium labor skill	Workpiece diameter: 0.8
Internal	Holes in workpiece; low production rates; low to medium labor skill	Hole diameter: 2
Honing	Holes in workpiece; low production rates; low labor skill	Spindle diameter: 2
Lapping	Flat, cylindrical or curved; high production rate; low labor skill	Table diameter: 1.2
Ultrasonic machining	Holes and cavities with various shapes; suitable for hard and brittle materials; medium labor skill	-

Adapted from: Kalpakjian and Schimid (2006)

2.3 SURFACE GRINDING

Surface grinding involve of placing the workpiece material on the bed, and clamp with magnetic chuck. The grinding occurs when the longitudinal bed tranverse, then the grinding wheel make the contact with the workpiece. The abrasive removes the chips on the material when the contact occurs.

Chati'opadhyay and Paul (1995) stated that the grinding process has some basic characteristics, such as high specific energy and high grinding zone temperature which are identified as the main cause of several related problems in grinding process. Its generate the cracks on surface integrity and increase the roughness of the surface.

Figure 2.2: Surface grinding machine

To reduce these problems, previous researchers did many studies (Fathallah et al., 2009; Choi et al., 2001; Chaitopadhyaya and Paul, 1995). Cutting speed, the stock removal rates and cutting fluid have got much attention in recent years (Chaitopadhyaya and Paul, 1995).This multitude of process parameters has made the selection of the adequate grinding conditions more and more difficult and gives rise to the need to conduct comparative studies to help finding the appropriate parameters depending on the ground material and selection criteria.

2.4 CUTTING FLUIDS

As Kalpakjian and Schimid (2006) claimed, the cutting fluid is an important in grinding process. Depending on the type of grinding, the cutting fluid used can be coolant, lubricant or both. The extensively usage of cutting fluid mainly to achieve the following results:

(i) Reduce friction and wear, therefore can improving tool life and the surface finish of the workpiece
(ii) Cooling the cutting zone, thus improving tool life and reducing the temperature and thermal distortion of the workpiece
(iii) Reduces force and energy consumption
(iv) Flush the cutting chips away from cutting zone
(v) Protect the machined surface from environmental corrosion

The mechanism of cutting fluids can penetrate the important rake face of the tool and influence the cutting process. Cutting fluid gains access to the tool-chip interface by seeping from the side of the chips by the capillary action of the interlocking network of surface asperities in the interface (Malkin and Guo, 2008; Chaitopadhyaya and Paul, 1995). Commonly, four basic cutting fluids used widely in machining operation as stated by Kalpakjian S.and Schimid S. (2006). There are:

(i) Oils: also called straight oil, including mineral, animal, vegetables, compounded, and synthetic oil typically are used for low-speed operation which temperature rise is not significant
(ii) Emulsion: also called soluble oils, mixture of oil and water and additives
(iii) Semi-synthetics
(iv) Synthetics